CLAIMS

1. An anode effluent control method for a fuel cell power plant comprising a fuel cell stack (1) which performs power generation using anode gas having hydrogen as a main component, the anode gas being discharged from the fuel cell stack (1) as anode effluent following a power generation reaction, a return passage (5) which re-circulates the anode effluent into the anode gas, and a purge valve (8) which discharges the anode effluent in the return passage (5) to the outside of the passage, the control method comprising:

calculating a first energy loss caused by an increase in a non-hydrogen component in the anode gas while the purge valve (8) is closed (S7, S28);

calculating a second energy loss which corresponds to an amount of hydrogen lost from the anode gas when the purge valve (8) is opened (S8, S29);

maintaining the purge valve (8) in a closed state when the second energy loss is larger than the first energy loss (S10, S31); and

opening the purge valve (8) when the second energy loss equals or falls below the first energy loss (S10, S11, S31, S32).

2. The anode effluent control method as defined in Claim 1, wherein the non-hydrogen component includes nitrogen and water vapor.

3. The anode effluent control method as defined in Claim 2, wherein the control method further comprises:

calculating a nitrogen partial pressure of the anode gas in accordance

with a duration of the closed state of the purge valve (8) (S3, S23);

determining a temperature of the fuel cell stack (1) (S4, S25);

calculating a water vapor partial pressure of the anode gas on the basis of the temperature of the fuel cell stack (1) (S5, S26);

calculating a hydrogen partial pressure of the anode gas by subtracting the nitrogen partial pressure and the water vapor partial pressure from an anode gas pressure (S6, S27); and

calculating the first energy loss on the basis of variation in the hydrogen partial pressure (S7, S28).

4. The anode effluent control method as defined in Claim 3, wherein the fuel cell stack (1) comprises an anode (1A) which is exposed to the anode gas, a cathode (1b), and an electrolyte membrane (1C) disposed between the anode (1A) and the cathode (1B), the fuel cell power plant further comprises an air supply device (2) which supplies air to the cathode (1B), and the control method further comprises calculating the nitrogen partial pressure of the anode gas on the basis of an amount of nitrogen in the anode gas which increases as nitrogen in the air permeates the electrolyte membrane (1C) from the cathode (1B) so as to reach the anode (1A) (S3, S23).

5. The anode effluent control method as defined in Claim 3, wherein the fuel cell power plant further comprises an anode gas passage (12) which supplies the anode gas to the fuel cell stack (1), a hydrogen supply device (3) which supplies hydrogen to the anode gas passage (12), a catalyst (14) which oxidizes

carbon monoxide in the anode effluent in the return passage (5), and an air supply device (2) which supplies air for oxidizing the carbon monoxide to the return passage (5), and the control method further comprises calculating an accumulated amount of the carbon monoxide in the anode gas that was contained in the hydrogen supplied to the anode gas passage (12) from the hydrogen supply device (3) (S42), comparing the accumulated amount to a predetermined value (S43), and supplying air to the return passage (5) from the air supply device (2) when the accumulated amount is larger than the predetermined value (S45).

6. The anode effluent control method as defined in Claim 5, wherein the control method further comprises preventing the air supply device (2) from supplying air to the return passage (5) when the purge valve (8) is open (S50).

7. The anode effluent control method as defined in Claim 5 or Claim 6, wherein the fuel cell power plant further comprises a pump (15) for pressurizing the anode effluent in the return passage (5) so as to introduce the anode effluent into the anode gas passage (12), and the control method further comprises reducing the rotation speed of the pump (15) when air is supplied to the return passage (5) from the air supply device (2) (S52).

8. The anode effluent control method as defined in any one of Claim 5 through Claim 7, wherein the control method further comprises calculating a partial pressure of carbon dioxide that is mixed into the anode gas as a result

of a carbon monoxide oxidation operation performed by the catalyst (14) (S24), correcting the nitrogen partial pressure of the anode gas on the basis of an amount of air supplied to the return passage (5) (S55), and calculating the hydrogen partial pressure by subtracting the water vapor partial pressure, the carbon dioxide partial pressure, and a corrected nitrogen partial pressure from the anode gas pressure (S28).

9. The anode effluent control method as defined in any one of Claim 5 through Claim 8, wherein the fuel cell power plant further comprises a recording device (16) which pre-records a carbon monoxide content of the hydrogen that is supplied by the hydrogen supply device (3), and the control method further comprises calculating the accumulated amount of carbon monoxide in the anode gas on the basis of the carbon monoxide content recorded in the recording device (16) (S42).

10. The anode effluent control method as defined in any one of Claim 3 through Claim 6, wherein the control method further comprises calculating the nitrogen partial pressure of the anode gas as a value which increases as a duration of the closed state of the purge valve (8) lengthens (S3, S23).

11. The anode effluent control method as defined in any one of Claim 3 through Claim 6, wherein the control method further comprises calculating the water vapor partial pressure of the anode gas as a value which increases as a temperature of the fuel cell stack (1) rises (S5, S26).

12. The anode effluent control method as defined in any one of Claim 1 through Claim 6, wherein the control method further comprises calculating the second energy loss as a value which decreases in accordance with a duration of the closed state of the purge valve (8) (S8, S29).

13. An anode effluent control device for a fuel cell stack (1) which performs power generation using anode gas having hydrogen as a main component, the anode gas being discharged from the fuel cell stack (1) as anode effluent following a power generation reaction, the device comprising:

a return passage (5) which re-circulates the anode effluent into the anode gas;

a purge valve (8) which discharges the anode effluent in the return passage (5) to the outside of the passage; and

a programmable controller (11) programmed to:

calculate a first energy loss caused by an increase in a non-hydrogen component in the anode gas while the purge valve (8) is closed (S7, S28);

calculate a second energy loss which corresponds to an amount of hydrogen lost from the anode gas when the purge valve (8) is opened (S8, S29);

maintain the purge valve (8) in a closed state when the second energy loss is larger than the first energy loss (S10, S31); and

open the purge valve (8) when the second energy loss equals or falls below the first energy loss (S10, S11, S31, S32).

14. The anode effluent control device as defined in Claim 13, wherein the non-hydrogen component includes nitrogen and water vapor.

15. The anode effluent control device as defined in Claim 14, wherein the controller (11) is further programmed to:

calculate a nitrogen partial pressure of the anode gas in accordance with a duration of the closed state of the purge valve (8) (S3, S23);

determine a temperature of the fuel cell stack (1) (S4, S25);

calculate a water vapor partial pressure of the anode gas on the basis of the temperature of the fuel cell stack (1) (S5, S26);

calculate a hydrogen partial pressure of the anode gas by subtracting the nitrogen partial pressure and the water vapor partial pressure from an anode gas pressure (S6, S27); and

calculate the first energy loss on the basis of variation in the hydrogen partial pressure (S7, S28).

16. The anode effluent control device as defined in Claim 15, wherein the fuel cell stack (1) comprises an anode (1A) which is exposed to the anode gas, a cathode (1b), and an electrolyte membrane (1C) disposed between the anode (1A) and the cathode (1B), the device further comprises an air supply device (2) which supplies air to the cathode (1B), and the controller (11) is further programmed to calculate the nitrogen partial pressure of the anode gas on the basis of an amount of nitrogen in the anode gas which increases as nitrogen in the air permeates the electrolyte membrane (1C) from the cathode (1B) so

as to reach the anode (1A) (S3, S23).

17. The anode effluent control device as defined in Claim 15, wherein the device further comprises an anode gas passage (12) which supplies the anode gas to the fuel cell stack (1), a hydrogen supply device (3) which supplies hydrogen to the anode gas passage (12), a catalyst (14) which oxidizes carbon monoxide in the anode effluent in the return passage (5), and an air supply device (2) which supplies air for oxidizing the carbon monoxide to the return passage (5), and the controller (11) is further programmed to calculate an accumulated amount of the carbon monoxide in the anode gas that was contained in the hydrogen supplied to the anode gas passage (12) from the hydrogen supply device (3) (S42), compare the accumulated amount to a predetermined value (S43), and supply air to the return passage (5) from the air supply device (2) when the accumulated amount is larger than the predetermined value (S45).

18. The anode effluent control device as defined in Claim 17, wherein the controller (11) is further programmed to prevent the air supply device (2) from supplying air to the return passage (5) when the purge valve (8) is open (S50).

19. The anode effluent control device as defined in Claim 17 or Claim 18, wherein the device further comprises a pump (15) for pressurizing the anode effluent in the return passage (5) so as to introduce the anode effluent into the anode gas passage (12), and the controller (11) is further programmed to

reduce the rotation speed of the pump (15) when air is supplied to the return passage (5) from the air supply device (2) (S52).

20. The anode effluent control device as defined in any one of Claim 17 through Claim 19, wherein the controller (11) is further programmed to calculate a partial pressure of carbon dioxide that is mixed into the anode gas as a result of a carbon monoxide oxidation operation performed by the catalyst (14) (S24), correct the nitrogen partial pressure of the anode gas on the basis of an amount of air supplied to the return passage (5) (S55), and calculate the hydrogen partial pressure by subtracting the water vapor partial pressure, the carbon dioxide partial pressure, and a corrected nitrogen partial pressure from the anode gas pressure (S28).

21. The anode effluent control device as defined in any one of Claim 17 through Claim 20, wherein the device further comprises a recording device (16) which pre-records a carbon monoxide content of the hydrogen that is supplied by the hydrogen supply device (3), and the controller (11) is further programmed to calculate the accumulated amount of carbon monoxide in the anode gas on the basis of the carbon monoxide content recorded in the recording device (16) (S42).

22. The anode effluent control device as defined in any one of Claim 15 through Claim 18, wherein the controller (11) is further programmed to calculate the nitrogen partial pressure of the anode gas as a value which increases as a

duration of the closed state of the purge valve (8) lengthens (S3, S23).

23. The anode effluent control device as defined in any one of Claim 15 through Claim 18, wherein the controller (11) is further programmed to calculate the water vapor partial pressure of the anode gas as a value which increases as a temperature of the fuel cell stack (1) rises (S5, S26).

24. The anode effluent control device as defined in any one of Claim 13 through Claim 18, wherein the controller (11) is further programmed to calculate the second energy loss as a value which decreases in accordance with a duration of the closed state of the purge valve (8) (S8, S29).